Use NEMI First:
The Role of the *National Environmental Methods Index* in Monitoring Design

Lawrence H. Keith, Instant Reference Sources, Inc., Monroe, GA
Daniel J. Sullivan, US Geological Survey, Madison, WI
James A. Boiani, DynCorp, Alexandria, VA
Herbert J. Brass, US Environmental Protection Agency, Cincinnati, OH
Charles A. Peters, US Geological Survey, Madison, WI
Katherine T. Alben, New York State Dept. Health, Albany, NY

Biosketches

Larry Keith chairs the NEMI workgroup and has over 35 years of experience with developing and using environmental methods. His current work involves developing an expert system for systematic planning with environmental monitoring and private consulting through Instant Reference Sources, Inc. **Dan Sullivan** is the lead developer of the NEMI database and website interface. A hydrologist with the USGS, he has over 17 years of experience in the fields of water quality and biology and associated databases. Mr. Sullivan is also the Associate Study Unit Chief for the Western Lake Michigan Drainages NAWQA Study Unit and the Webmaster for the Wisconsin District of the USGS. **James Boiani** is an Environmental Chemist at DynCorp, and the Work Assignment Manager for NEMI under EPA's Sample Control Center (SCC) contract. Mr. Boiani specializes in the development of environmental monitoring methods and government regulations. **Herb Brass** is the Analytical Methods Team Leader in the Office of Ground Water and Drinking Water at the USEPA and has over 25 years of experience in managing environmental methods and monitoring programs. He is also Co-Chair of the Methods and Data Comparability Board under whose auspices NEMI is being developed. **Charlie Peters** manages the Multidisciplinary Water-Quality Assessment team in the USGS, Wisconsin District office, acts as the study unit chief for the Western Lake Michigan Drainages NAWQA study, and as co-chair of the National Methods and Data Comparability Board. **Katherine Alben** is a Research Scientist at New York State Dept. of Health and a faculty member in the Dept. of Environmental Health and Toxicology, State University of New York at Albany. For 25 years, she has contributed to development of analytical methods, primarily to assess water quality. She co-chairs the MDCB Biology Workgroup, which has helped to prepare biological methods for NEMI.

Abstract

This hands-on workshop will allow users to experience the depth and power of a newly available source of method summaries. The National Environmental Methods Index (NEMI) is a database of chemical and biological method summaries that is searchable over the Internet. It is designed to be the first source that people will typically use when making decisions about which method(s) will best serve their project-specific needs.

The selection of field procedures and analytical methods is one of the most important parts of environmental program planning. This critical step will now be much faster and easier with the use of NEMI to evaluate chemical, physical, radiochemical, microbiological and biological field and laboratory methods. Rapid comparisons of critical parameters of methods for use with methods selection and (or) methods modification and data comparability are easily made using data fields such as analytes, instrumentation, detection levels, accuracy, and precision. The NEMI database ensures that the consideration of analytical methods is a more active part of planning and implementation of programs. Method summaries in NEMI are linked to full methods if they are not copyrighted (for example, those from USEPA and USGS), and to the method sources for privately published methods (for example, those from Standard Methods, ASTM, etc.).

NEMI's Background

The selection of analytical methods is a critical part of environmental monitoring program planning. During planning, monitoring objectives usually influence criteria for the program. Limitations of analytic techniques (e.g., sensitivity, selectivity, accuracy, precision, etc.) often determine the capability and evaluative power of the entire program, and hence proper selection of analytical methods is paramount. On the other hand, sometimes there are so many analytical methods available that it can be difficult to select the one that will best meet project-specific needs. Project-specific methods needs are typically governed by the sample media (i.e., water, air, soil, solid or liquid wastes, etc.) and matrix (e.g., drinking water, wastewater, ground water, sea water, etc.), as well as requirements for sensitivity, selectivity, accuracy, precision, and cost.

Comparing method quality and suitability from the methods themselves is difficult because method protocols contain detailed instructions, they typically exist in different formats, they are often lengthy, and they may not contain all of the information needed to compare one method versus another. Thus, there is the need for a database of method summaries which contain all of the fields of information necessary for method comparison.

NEMI's Mission, Objective, and Purpose

NEMI's mission is *"to allow rapid communication and comparison of critical parameters of methods for use with methods selection and/or methods modifications and data comparability."*

NEMI's objective is to provide a user-friendly, database of method summaries that is searchable over the World Wide Web. Its purpose is to support monitoring program planning, first with water programs and then to support additional media. As such, it is part of a larger effort to improve comparability of water quality data and environmental analytical data quality nationwide. Its development under the Methods Data and Comparability Board ensures that data on critical aspects of methods will receive multi-organizational review and meet interagency needs in this complex technical discipline.

What NEMI Is and Is Not

NEMI is not a database of analytical methods. Rather it is a database of method summaries that include all available information, including literature citations, from which to make a scientific comparison of one method versus another, in terms of their ability to meet project-specific requirements. It is a database that is easily searchable on the Internet and, as such, does not require sophisticated software to run it - only a modern browser and an Internet connection. However, links to the full methods (if they are public domain) or to their commercial sources (if they are copyrighted) are provided, so that once a decision is made as to which method is likely to meet a user's needs, it can be obtained.

NEMI's Content and Features[1]

Method summaries currently include those involving laboratory methods and sample preparation for organic and inorganic analytes, nutrients, radiochemicals, and microbiological "analytes" in water. Later versions of NEMI will include biological and field analytical methods for water, soils and solids, air, and other matrices. There are over 30 fields of information for each method summary. These are designed to provide information useful for methods comparison, but not for using a method.

Many of the methods, especially the older ones, do not have information available for all of the fields; however, when information is available, it is included in the database. In fact, the absence of critical information is, in itself, useful for methods comparison. If, for example, among several methods available for consideration for a

[1] The NEMI website is rapidly evolving and its appearance and functionality are subject to change.

particular analyte, some are missing important QA/QC metadata information and others have this data, the methods having this information will tend to be the methods of choice, all other criteria having been met. Method summaries are being contributed by government agencies and private sector organizations and companies. Current contributions by government agencies include the U.S. Environmental Protection Agency, the U.S. Geological Survey, and the Department of Energy. Current private sources of method summaries include the American Society for Testing and Materials, AOAC International (formerly the Association of Official Analytical Chemists), Standard Methods for the Examination of Water and Wastewater, IDEXX, Strategic Diagnostics Inc., EnviroLogix, Hach and Syngenta. U.S. EPA methods are further sub categorized to include those from the Office of Research and Development -- National Exposure Research Lab (formerly EMSL), the Office of Water -- Office of Science and Technology (Engineering and Analysis Division), Office of Ground Water and Drinking Water -- and the Office of Solid Waste. The database will contain information from over 600 methods when released to the public and it is expected to grow rapidly as its utility is discovered. The only requirement for submitting method summary information to NEMI is that the method be published and available to the public. Availability may be free, as with public domain methods, or purchased, as with copyrighted methods from some non-profit organizations and also private for-profit companies. Methods will be able to be submitted using a variety of methods, including spreadsheets and on-line forms. In all cases, submitted methods information is carefully peer reviewed for technical content and consistency with respect to units of measurement, database business rules, and meta data prior to its entry into the database.

The database can be searched by numerous parameters including:

- Chemical or Biological parameters,
- Types of Chemical/Biological parameters (organic, inorganic, radiochemical, microbiological, etc.)
- Method,
- Method source (e.g., EPA, USGS, DOE, Standard Methods, ASTM, AOAC, IDEXX, Strategic Diagnostics Inc., EnviroLogix, Hach, Syngenta, etc.)
- Multiple chemicals (by primary name, synonym, or Chemical Abstracts Service (CAS) number,
- Medium (although in the first phase only water methods will be included),
- Key words, and
- Metadata (e.g., detection level, precision, and accuracy).

Typical users of NEMI will include:

- Regulators, analysts, engineers, and managers from government regulatory agencies,
- Scientists from the regulated community,
- Scientists from the laboratory and engineering support communities,
- Volunteer monitoring groups,
- Academic researchers,
- The international monitoring community, and
- Watershed planning organizations

As the variety and kinds of method summaries in NEMI increases to include matrices other than water, the users of NEMI will likewise expand beyond water-related sciences.

Examples of NEMI Use

Perhaps the easiest way to envision the power and utility of NEMI for evaluating methods comparability is with several examples. Eight examples are discussed below.

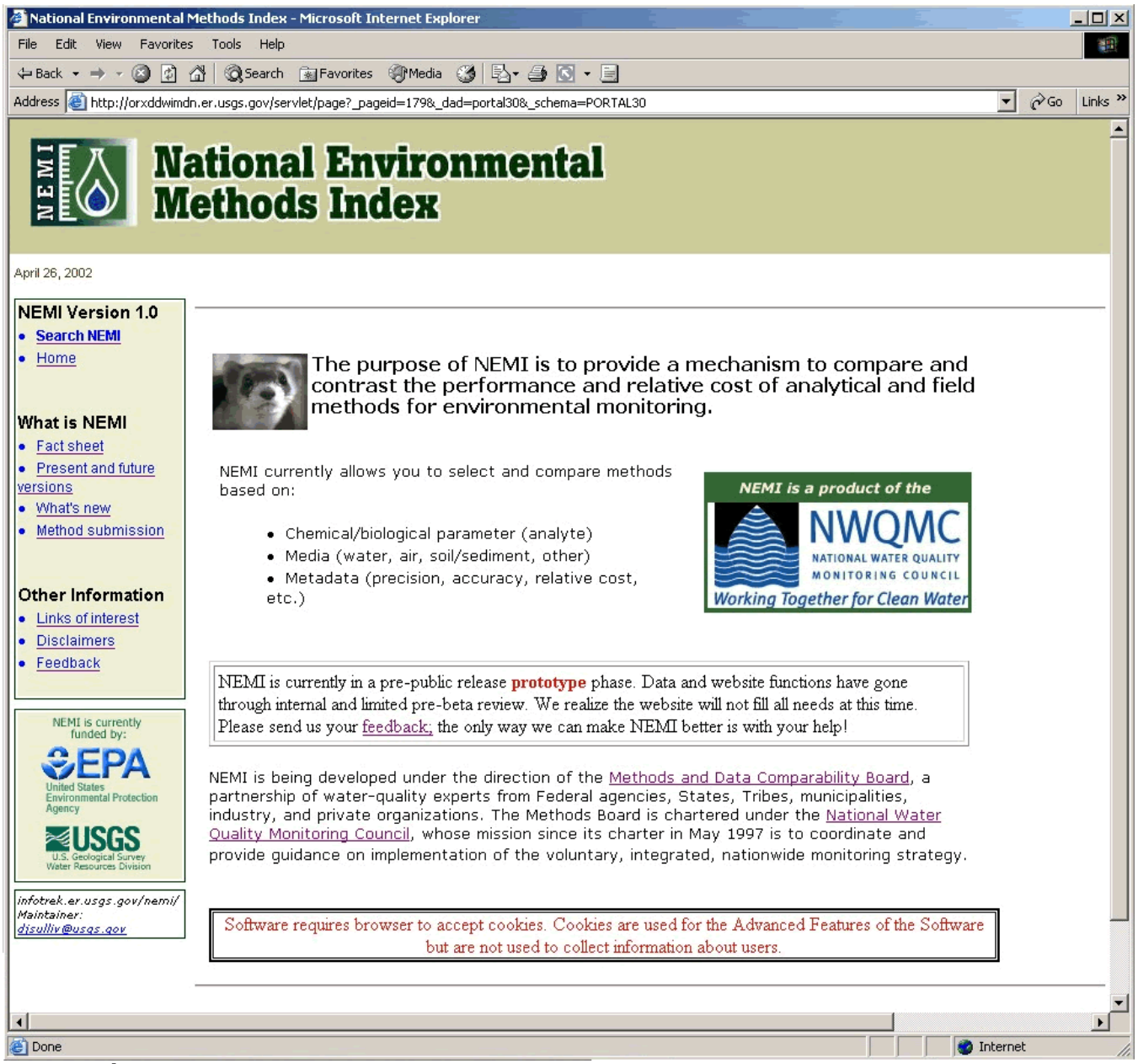

Figure 1. The NEMI Home Page

The home page screen (Figure 1) provides brief background information on NEMI, including links to the Methods and Data Comparability Board, under which development is conducted, the National Water Monitoring Council (parent organization of the Methods Board), database information, project description, contributing organizations, and other miscellaneous information including the newest features and additions of methods in NEMI. The Database Information link provides additional details concerning the data dictionary and business rules used to construct NEMI, definitions of the specific fields of information used in NEMI, a list of all methods currently in NEMI, and the Excel spreadsheet and on-line forms for submitting new methods information. An email form for comments and questions is also available on the home page.

The heart of NEMI is, of course, the methods searching capability. This is accessed from the home page using the link labeled "Search Methods." There are currently three options of searching for methods information.

1. Search by analyte and metadata,
2. General search by media, methods source, or analyte subcategory (analyte name is not required), or
3. Simple search by analyte in which the results can be ordered in different ways according to the user's priorities.

It is probable that the current three options of searching will be further refined prior to and after release to the public. Changes to search options will be driven by user needs and logical search algorithms developed to refine comparison of methods information in the database.

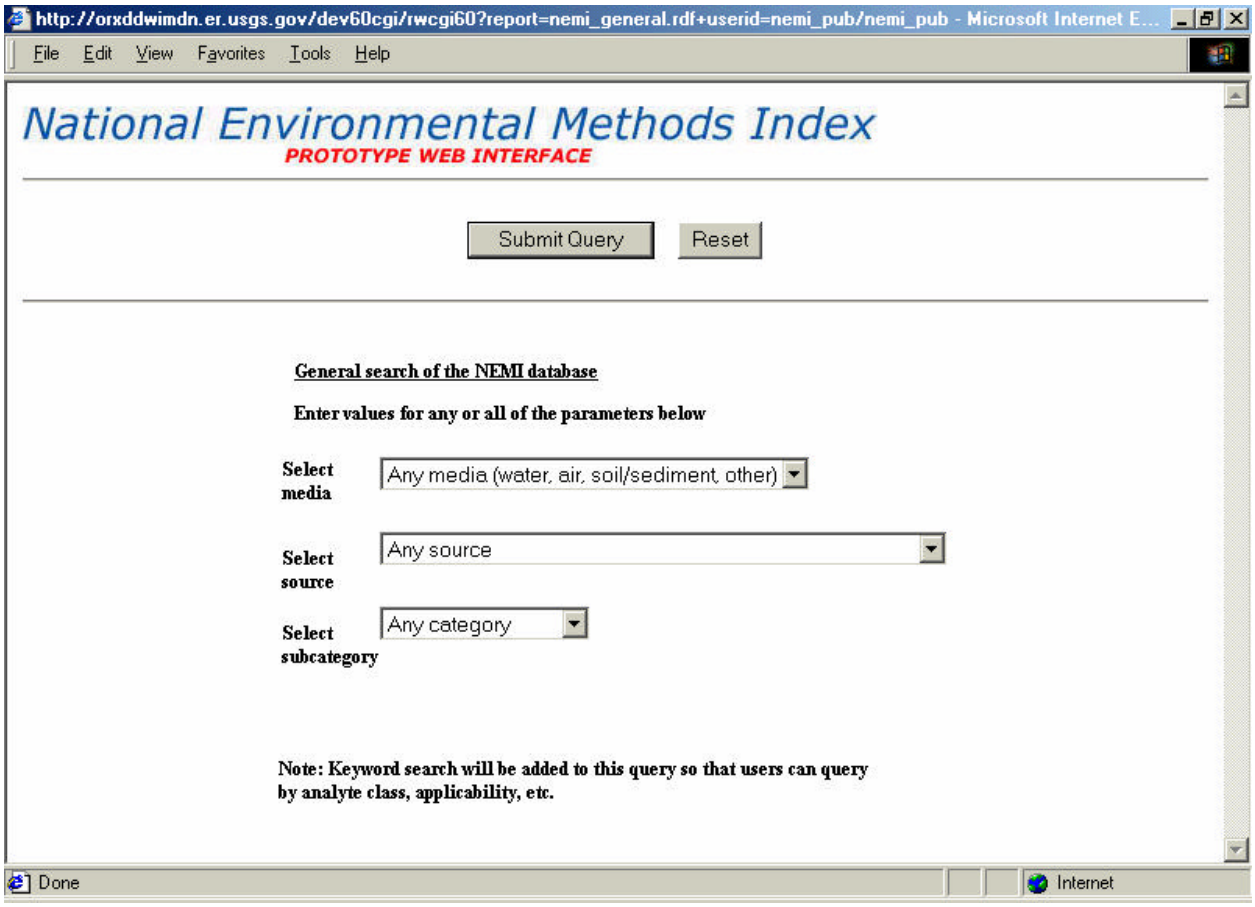

Figure 2. The General Search Option

The general search option of NEMI is the simplest to use but it also gives the largest number of returns for any parameter selected. However, the addition of searchable keywords, to be available when NEMI is released to the public, will help make this search significantly more useful. Currently water is the only available medium to select, but this will change as methods for other media are added in the future. Figure 3 shows the results of methods returned from the General Search Option looking for inorganic methods provided by ASTM. Clicking on any of the underlined (hyperlinked) method numbers in the left column provides the method summary.

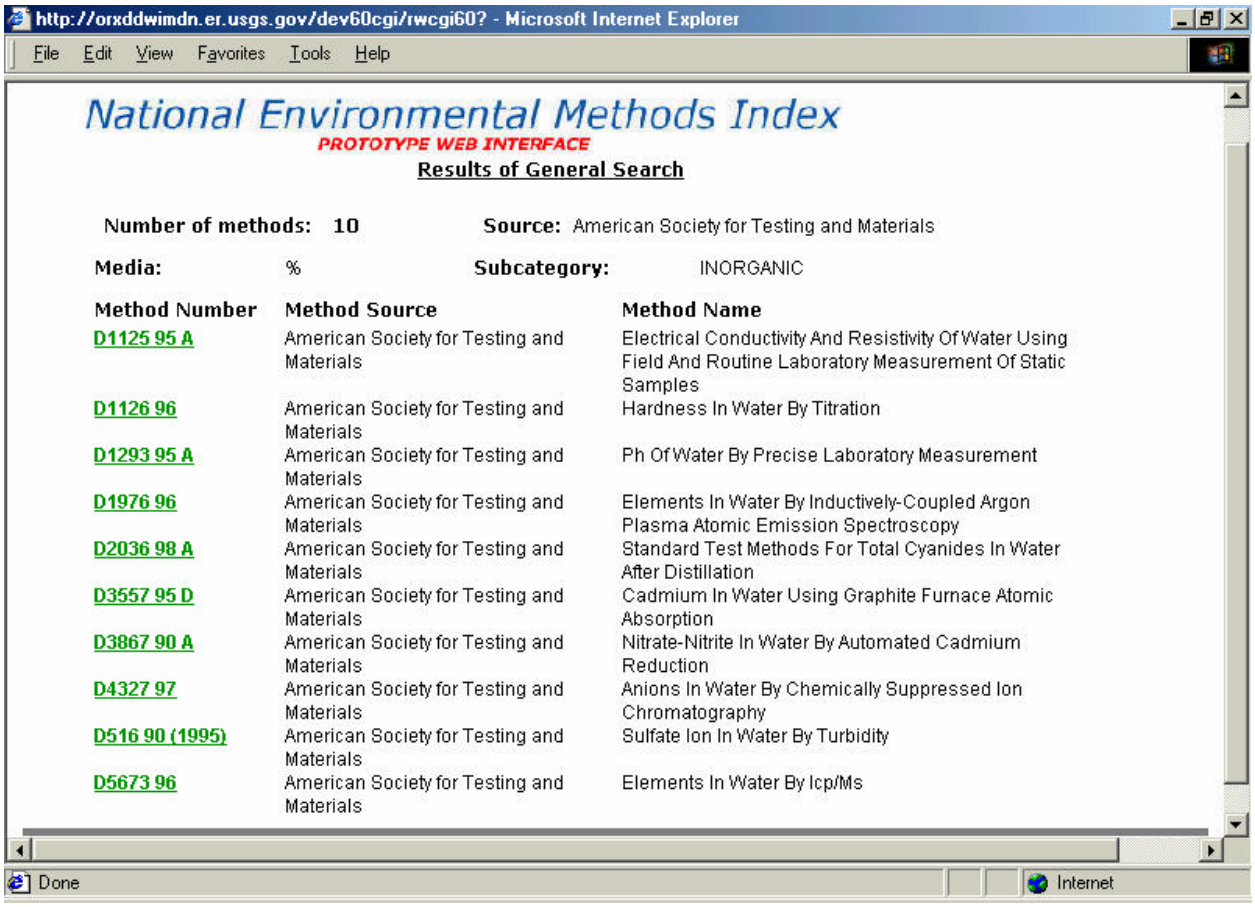

Figure 3. General Search Example for ASTM Inorganic Methods in NEMI

When the single analyte and metadata search is used with the analyte "cyanides" and a spectroscopic method is desired (Figure 4), 6 methods are found by the search when no metadata parameters are specified (Figure 5). By listing the metadata parameters in a table with other salient information (i.e., relative cost and type of instrumentation) the characteristics of each method, relative to project-specific needs, are easily compared. Additional details of each method are instantly available by clicking on the method number in the left column of the table. If any available instrumentation is acceptable, and a desired detection level of at least 0.01 mg/L is desired, then entering this additional metadata provides a more limited list of methods as shown in Figure 6. Of the four methods shown in this report, however, only one has associated accuracy and precision data. Clicking on Method D2036 98A provides the method summary details. These are partially shown in the screen print of Figure 7. Not shown are two other important hyperlinks:

1. a link to all the other analytes covered by the method, and
2. a link to the method source (in this case the ASTM home page).

In this example there are no other analytes besides cyanides that are covered by this method but many methods are applicable to multiple analytes - sometimes more than one hundred.

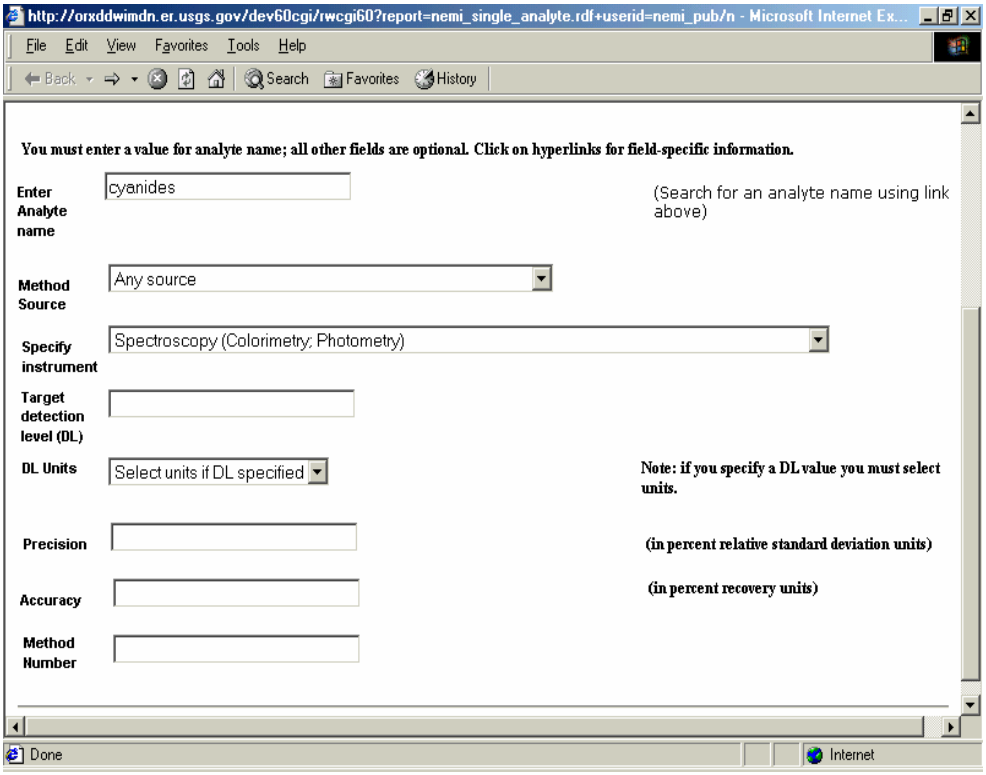

Figure 4. Single Analyte Search Specified for Cyanides Using Spectrophotometric Methods

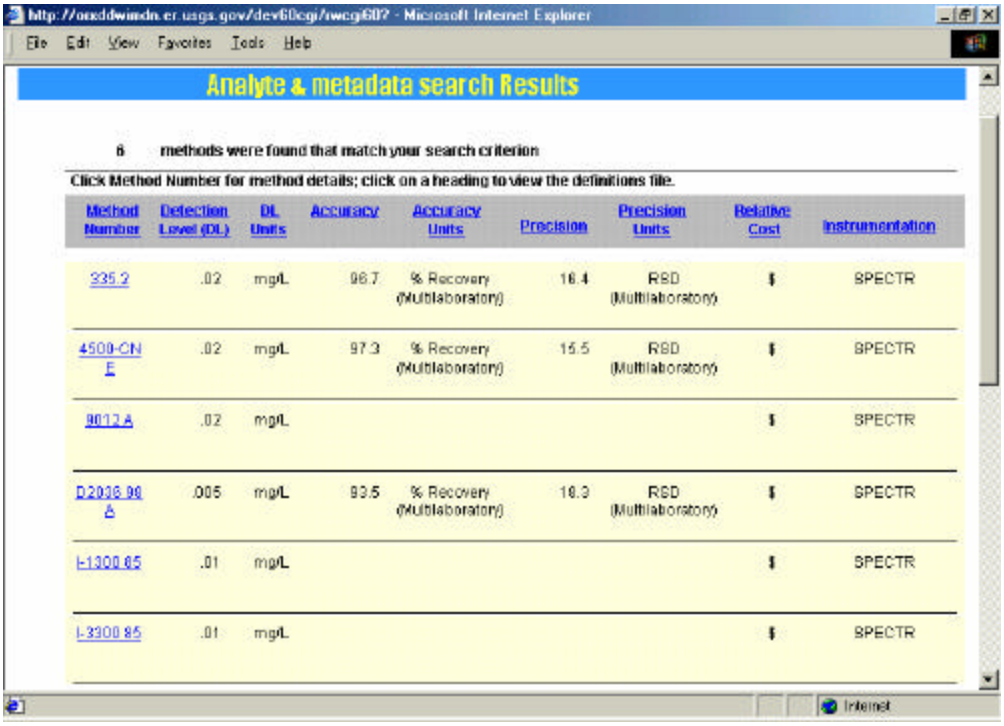

Figure 5. Results of NEMI Search for Cyanide Spectrophotometric Methods

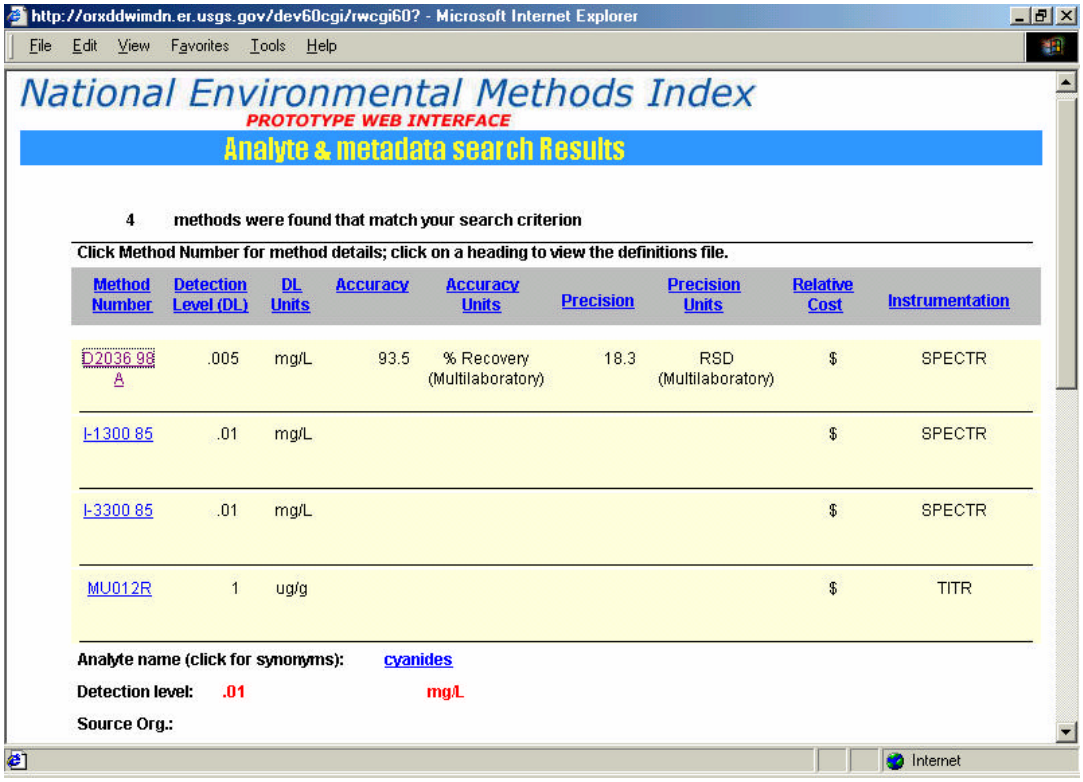

Figure 6. Search Results for Cyanides Methods With at Least 0.01 mg/L Detection Level and Using Any Instrumentation

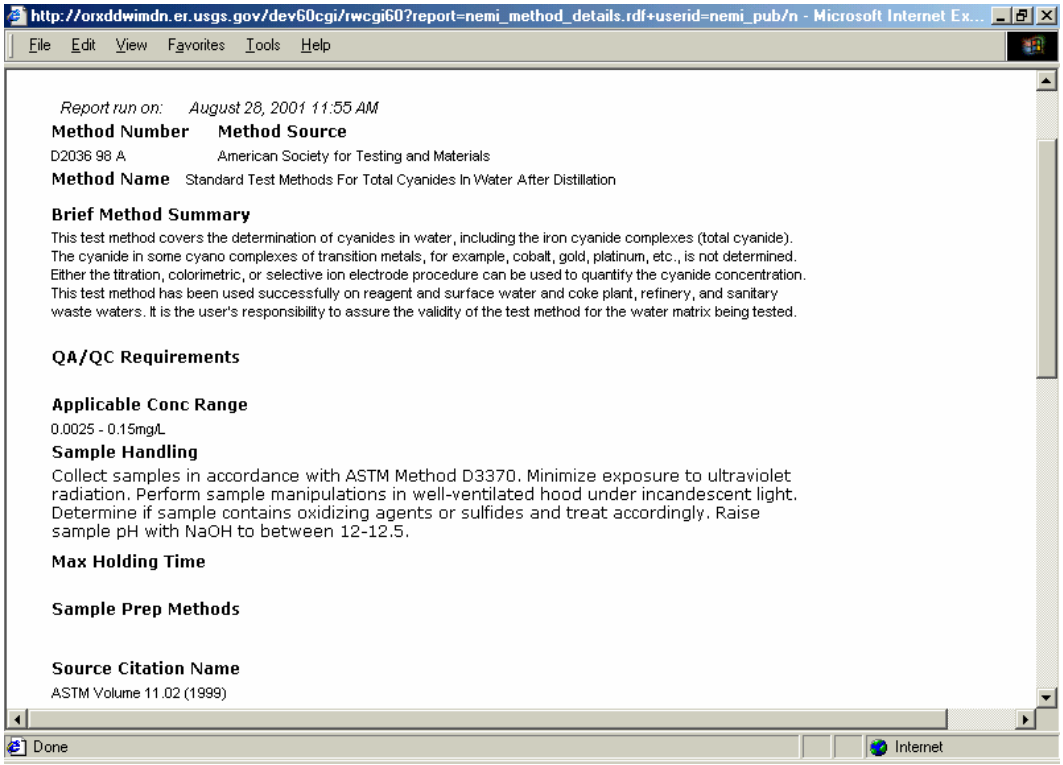

Figure 7. Partial Information Shown for ASTM Method D2036-98A

The third searching option is similar to the one described just above but differs in that the results of the search can be ordered with several priorities that are selected by the user. Figure 8 shows the options available for selection.

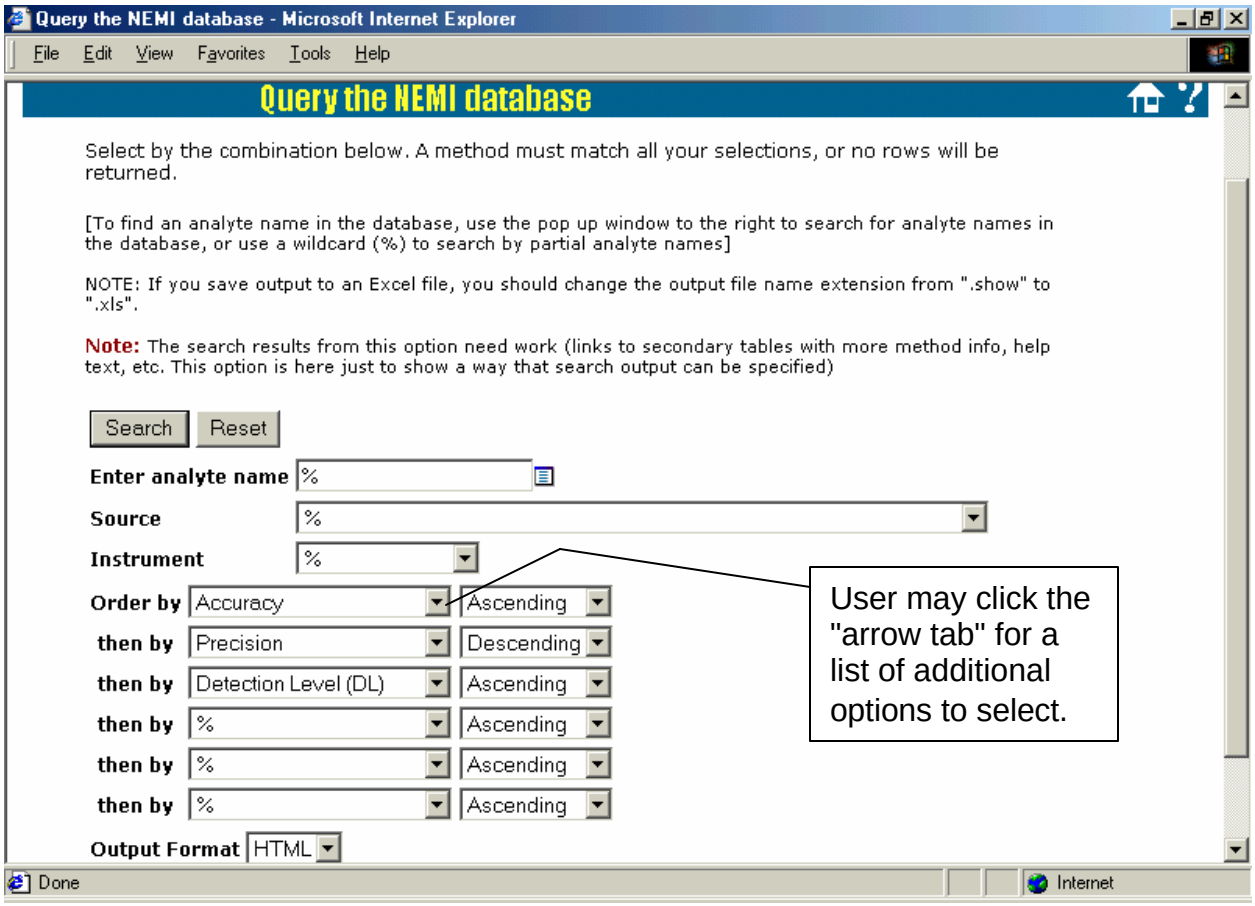

Figure 8. Option 3 Priority Arrangement Selections of Methods Found in NEMI

The advantage of this option is that when many methods are available for evaluation, as will occur in the future, they can all be viewed but ordering them by the user's priority will help compare the most important features. Note that the order of listings can be by either ascending or descending values. In addition to the obvious metadata selections of accuracy, precision, and detection level, the user may also select the analyte code number (i.e., CAS number for chemicals), the method source or source identifier method number, instrumentation, or accuracy or precision. These additional options are made by selecting the "arrow tab" in any of the dialog boxes and then selecting the category of choice from a list. In the future, the relative cost information will be an additional useful parameter for these advanced search functions.

Note that in this screen, and also in the Simple Analyte Search Option, that the exact analyte name must be entered. In the case of organic compounds this may be difficult either from correct spelling of the root name and prefixes and suffixes (e.g., p, p'-DDT, or 4,4'-DDT) as well as the many synonyms that are often associated with organic compounds. Therefore, a menu of names is available to eliminate typos or other spelling inconsistencies that could lead to not finding desired methods information in the database.

Figure 9 shows how useful this kind of search can be. When the "wildcard" symbol "%" is typed into the dialog box and followed by the root name "naphthalene" there are eight organic compounds currently found in the database. Clicking on any one of these instantly enters that compound into the database searching parameter under the analyte category.

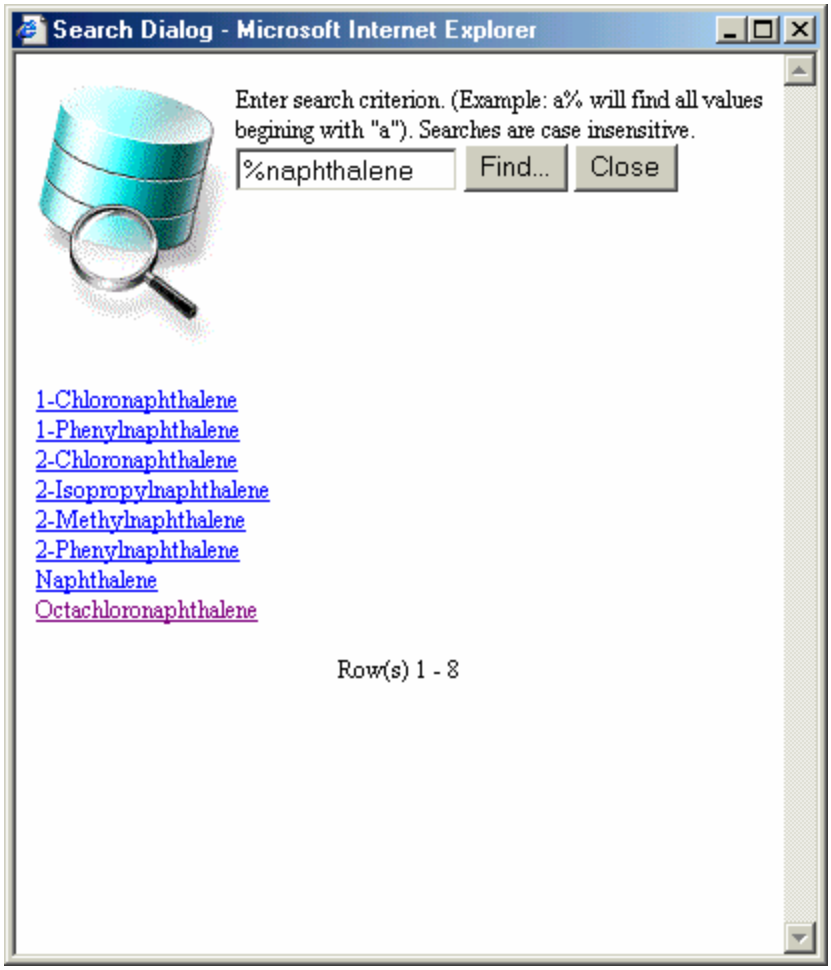

Figure 9. Example of Chemical Name Searches for Analyte Entry

Conclusion

There are many advanced features currently available and under development that will be available in the publicly released version of NEMI. Together, these features will provide the most powerful database of environmental methods information ever assembled for methods comparability. As the database grows in number and variety of methods, it will become an indispensable first option for methods comparison and selection for scientists and engineers planning environmental projects. It will also serve as an example of the kinds of data needed in order to adequately characterize method quality and performance as future methods are developed to take advantage of new instrumentation, techniques, and project-specific needs.

Acknowledgment

The U.S. EPA and the U.S. Geological Survey have provided direct funding to support the development of NEMI and other participating organizations have provided substantial in-kind support in terms of advice, attending meetings, and submitting method summaries.